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PRINCIPAL INVESTIGATORS:

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TITLE

Development of Integrated Pest Management Approaches for Wine Grape Growing Areas of Sonoma Valley

SUMMARY

The purpose of this project was to introduce and demonstrate innovative pest management practices to wine grape growers in Sonoma Valley, with the ultimate goal of reducing or eliminating pesticide use in wine grape production. The project was sponsored and directed by SVVGA grower members, with technical expertise provided by UC Cooperative Extension Farm Advisors and NRCS staff.

Much of this past year's effort has focused on the education and outreach component of the project. Since March 1997, we have organized monthly outdoor IPM Workshops at different vineyards on a variety of pest management topics. The subjects of the workshops, which were presented by the hosting vineyard managers, UC Cooperative Extension Farm Advisors, and the Project Coordinator, have included Pierce's Disease, eutypa, powdery mildew, mites, leafhoppers, weeds, and rootstock selection. The workshops were very hands-on and required growers' active participation. Information sheets on the different workshop topics have been compiled into a booklet and sent to SVVGA members.

The workshop sites were selected from vineyards owned or managed by the Sonoma Valley growers who make up the "Innovators Group." The Innovators Group consists of those vintners and growers who agreed to be actively involved in the IPM education program. These SVVGA members pledged to participate in the workshops regularly and offered the use of their vineyards as demonstration sites. This group represents both small and large vineyards from every corner of the valley. Several innovator growers manage more than 300 vineyard acres in the Valley, and others operate large, well-known estates such as Kunde, Glen Ellen, and Kenwood. In addition, more than 50 other growers asked to be put on the mailing list to be notified of workshops and other education programs. That number increased from 30 at the start of the program in March.

The larger grape growing community within Sonoma Valley was invited to attend our first annual Vineyard Tour and Field Day, held on July 10. More than 50 growers, vineyard managers, and vintners attended that event, which included tours of five of Sonoma Valley's best managed vineyards and IPM workshops on yellow star thistle control and Pierce's Disease.

The course of the education and outreach program was determined in large part by the results of a comprehensive survey developed by the principal investigators and mailed out to SVVGA vineyard owners and managers in September 1996. The SVVGA received a 67% response to the survey. (However, more than 80% of the Valley's vineyards are represented in that response - with either the vineyard owner or manager or both responding.) The survey asked vineyard owners and managers about their pest management practices, their knowledge of IPM techniques, and their opinion of conventional versus alternative or low-input agricultural methods. (The final report on the results was included in the March 1997 progress report.) The results were used by the principal investigators to identify those issues of local concern and develop education and outreach programs that target those issues.

RESULTS and DISCUSSION

In the first year of this project we identified the particular pest problems and pest management practices of Sonoma Valley wine grape growers, as well as growers' concerns and attitudes about conventional and alternative agricultural techniques. The focus of the second year of this project has been to develop an education and outreach program based on those findings, to demonstrate, implement and promote IPM practices in Sonoma Valley vineyards, with the ultimate goal of reducing conventional pesticide use throughout wine grape growing areas of California.

Objective 1. To demonstrate IPM techniques to wine grape growers in Sonoma Valley with the long-term goal of encouraging widespread voluntary adoption of these practices by the grower community.

Various IPM techniques, as well as their effectiveness and economic costs vs. conventional methods, were presented at monthly outdoor workshops. The workshops, held from 7:30 to 9:30 a.m. on the fourth Thursday of every month at one Sonoma Valley or another, have focused on topics of concern to local growers: Pierce's Disease, mites, leafhoppers, powdery mildew, eutypa, weeds, and rootstocks. (Handouts, photos enclosed). The workshops were very practical and hands-on. Growers were active participants and learned pest/disease identification, monitoring, and control techniques by doing. For example, the growers who attended the March workshop on Pierce's Disease studied the blue-green sharpshooter (the carrier of the disease) - as well as several look-alikes - through microscopes and learned how to identify it positively. They also learned how to monitor for the pest through the use of yellow sticky traps and sweep nets, and how to identify the insect's host plants. Participants also received the most current information about the disease, its symptoms and development, the life cycle of the blue-green sharpshooter, and options for control and for riparian vegetation management.

Each workshop generally began with an introduction by the hosting vineyard manager, followed by a presentation by UC Cooperative Extension Farm Advisors and the Project Coordinator, and then two or three practical exercises.

The most popular workshop of the year was the November session on rootstocks. More than double the usual number of participants came to hear experienced vineyard managers and representatives from nurseries talk about choosing the best rootstocks for a particular site.

An average of 15 growers attended each workshop. Three or four people were "regulars," but for the most part different growers came to different workshops, so we feel we reached a wider group than the attendance numbers would suggest.

Workshop participants were very enthusiastic about the meetings and said they found them informative and relevant. We had hoped more growers would show up to each workshop, but this has been difficult to achieve. Most of the grower members of SVVGA are the ones responsible for managing their vineyards - often large vineyards. They are the ones actually running the crews. That being the case, it is difficult for them to get away for two or three hours in the morning to attend a workshop. The fact that many have made that effort is a sign of real support.

Moreover, the growers who have attended have been the leaders of the grower community. Many manage relatively large vineyard acreage or they've been growing wine grapes for many years, and their opinion on vineyard management is sought by others.

We have found that one of the greatest benefits of these workshops has been the interaction among growers and the sharing of experiences and ideas that went on at the meetings. At the most basic level, these workshops offered growers an opportunity to meet and exchange information, as well as glean new information. It is our hope that these new relationships will continue after the end of this project and will help sustain innovative growing practices into the future.

Objective 2. To develop a strong education and outreach program and extend it to wine grape growers outside of Sonoma Valley.

On July 10 we held the first annual Vineyard Tour and Field Day as part of this project. Just over 50 growers and vintners paid $25 each to attend the all-day event.

We hosted the Field Day in conjunction with another local grant project - the Vineyard Demonstration project, which is administered by the Southern Sonoma Resource Conservation District. The TAC members of our project voted to hold a joint Field Day for two reasons. One, the target audience was almost identical (same mailing lists), and we felt that holding two events around the same time would compete with each other and lower attendance for both. Second, the fact that our funding was reduced this year from $30,000 to $25,000 meant that we had less money for hosting our own big event.

Those attending the Field Day toured five exceptionally well-managed vineyards employing IPM techniques. They heard the managers of those vineyards talk about how they deal with various pest management problems and they attended IPM workshops on Pierce's Disease and on weed management. Joe DiTomaso, a UC Davis weed scientist and expert on yellow star thistle control, enthralled the group with his presentation on that weed, which is a major problem in Sonoma Valley vineyards.

The principal investigators and other grower-leaders in Sonoma Valley spoke on different aspects of wine grape production on the bus rides between vineyards.

Objective 3. To promote adoption of IPM practices throughout the grape growing regions of California.

Toward this goal, we compiled information sheets on the different workshop topics, bound them into a booklet, and will mail them to the SVVGA innovators. (Copies of information sheets enclosed.) The booklet is intended as a quick reference on environmentally-friendly vineyard management practices.

These information sheets will also be used by the Southern Sonoma Resource Conservation District to update the Vineyard Management Practices manual. The updated manual will then be available to vineyard owners and managers throughout the county and in other wine grape growing regions.

Botrytis Bunch Rot

Every growing season bunch rots of grapes cause losses due to direct reduction in yields and decrease wine quality. Rotting grapes in vineyards often contain more than one microorganism. The most important fungus responsible for bunch rot is *Botrytis cinerea.* This fungus can grow on any plant material that is succulent, stressed or damaged. The chemical enzymes produced by the fungus can destroy the integrity of a grape berry within a few days. Secondary organisms then become established on the diseased berry. Tight, thin-skinned berries are the most susceptible to Botrytis bunch rot. In general, white varieties are more susceptible than red varieties.

Symptoms

Bunch rot begins when individually infected berries within the cluster turn brown due to enzymes produced by the fungus. The enzyme break down the cuticle of the berry causing what is known as 'slipskin' since the skin easily slips of the berry. Infected berries split and leak, thus allowing the pathogen to grow and sporulate on berry surfaces and spread to adjoining berries by mid-season. When moisture is high the fungi will produce the characteristic gray mold.

Early season shoot blight may occur following spring rains. Flowers can become infected during bloom.

Disease Cycle

The fungus overwinters as dormant resistant structures on mummified fruits. After rains or irrigation in the spring, these dormant structures produce gray spores, which are spread by air currents. Spore germination requires free water for a definite period of time depending on temperature and nutrients such as sugars. Late season infections are most severe when relative humidity exceeds 92%, free moisture is present on the fruit surface, and temperatures range from 58° to 82°F. Berries that have been damaged by birds, insects, mechanical damage, or powdery mildew may become infected at any time because the juice in the berry can provide the necessary water and nutrients for fungal growth.

Under moist conditions early in the spring, the spores can infect the grape flowers, young leaves and succulent young shoots (shoot blight). Infected shoots wilt and break off at the base.

Prevention and Environmentally Sensitive Controls

Sanitation is very important, remove and destroy all clusters that remain after harvest. Clusters left on vines or on the vineyard floor from the previous season can be a source of spores the following spring.

Excellent control has been achieved using canopy management and leaf removal. Removal of four to five basal leaves has resulted in significantly reduced incidence and severity of disease. Remove leaves around clusters at late bloom-cluster set. The objective is to increase exposure of the grape clusters to air and light so that they dry out more quickly after a wetting.

Canopy management through trellis systems, pruning methods, shoot positioning, shoot thinning and hedging can be manipulated to increase air and light penetration to the clusters. The more layers of leaves surrounding the cluster the more optimum conditions will be for development of *Botrytis* bunch rot.

Overhead irrigation creates high relative humidity; this favors the development of the pathogen. If overhead irrigation is used, time it to avoid having more than 15 hours of free moisture on the clusters, including the time it takes to dry the clusters completely.

To prevent flower infection, a fungicide application may be warranted if wet weather occurs during bloom. Also, late in the season fungicide treatment may be needed if rain is expected, to prevent bunch rot in mature grapes. Apply sprays only after environmental conditions conducive to the growth of the fungus have occurred. It is critical to obtain optimum coverage.

Eutypa

Eutypa dieback, caused by the fungus *Eutypa lata* is a chronic disease of grapevines that reduces vineyard productivity and longevity. Economic losses due to Eutypa dieback may be minor in early years but the most damaging effects are observed on older vines, which have large pruning wounds caused by drastic cutting to retrain them. For many growers Eutypa dieback can reduce the length of time a vineyard can be considered economically viable.

Symptoms

Eutypa dieback delays shoot emergence in the spring. Affected vines, distributed at random throughout the vineyard, show individual weak and stunted shoots with shortened internodes. At first leaves on affected shoots are small, chlorotic and misshapen. These leaves sometimes appear cupped, distorted, and marginally necrotic with small areas of dead interveinal tissue. Later in the season they take on a tattered, scorched appearance. Many of the flower fall off, most berries that do establish on these shoots fail to mature. If the shoots are only mildly affected the tattered leaves appear on just the first few nodes and subsequent growth is normal. The disease appears first in one or two spurs and spreads in the following seasons to adjacent spurs, eventually killing the arm or cordon. When Eutypa kills the entire vine, strong suckering occurs from the still healthy roots.

The symptom in the wood is darkened cankers that develop in the vascular tissue. The cankers are found near old pruning wounds. In its early stages, a cross-section of the cordon or trunk will reveal the canker as a wedge-shaped darkened area (see figure). Trunk cankers can be extensive in length.

Disease Cycle

Infection occurs through pruning wounds. Pruning wounds are susceptible to infection for several weeks following pruning. Spores are discharged during and soon after rainfall. Spores that land on the pruning wounds germinate in wood cells and the fungus invades the wood. Spores are produced in old Eutypa infections and are carried by the wind for hundreds of miles. Hosts such as oaks, apricots, cherries and grapes are a source of this disease. Pruning tools cannot spread the disease.

It takes several growing seasons before visible cankers or symptoms develop around an infected wound. Once an arm or portion of the vine has been killed, it takes several more years before the spore sacs are produced on old infected tissue. High moisture is necessary for the formation of the spore sacs. Once the spore sac is formed it continues to discharge ascospores for five years. Spore sacs are present in the lower trunk of previously infected dead vines.

Prevention and Environmentally Sensitive Controls

The first line of defense is preventing the infection of pruning wounds. Prevention should be practiced annually, especially on young vines to ensure their longevity. Wound protection offers much better control prospects than eradication once the disease has become established.

To reduce the chances of infection treat pruning wounds with fungicides. All new pruning wounds are susceptible to infection by Eutypa for several weeks, regardless of their size, the age of he wood, or the date of pruning. Cut surfaces are treated by hand with sprayers or daubed paints on the same day vines are pruned. For best results the fungicide should be applied twice.

Dreft detergent (20-30% solutions) has been used as a wound protectant because it provides an effective barrier to infection that lasts much longer than fungicides. However, the use of soap as a fungicide is technically illegal since it is not registered as a pesticide. The Agricultural Commissioner may cite growers applying soaps. Soaps can be phytotoxic to grapevines. Other brands of soap or detergent have not been evaluated and could cause damage.

It is preferable to prune in dry weather. Delaying pruning until February or March can reduce the chance of infection. Pruning wounds made late in the season are susceptible to infection for a shorter period of time than wounds made earlier when the vine is dormant. When vines are pruned in late winter-early spring they are beginning to come out of dormancy and the period of wound susceptibility is reduced to 10 to 14 days because of faster healing. When vines are dormant wounds are susceptible to infection for 4 to 5 weeks. Another advantage of delayed pruning is that in most years fewer spores are produced and released during these months. Pruning can be safely delayed until bud swell without harming the vines.

If delayed pruning is not possible; another option is double pruning in cordon-trained vineyards. The first pruning is made early in the season during December and January. At this time, the vines are "hedged" back by hand or mechanically to long spurs or rods approximately 12-18 inches long. The vines are pruned a second time in February or March to make the final cuts and shorten spurs to their normal length. Any infection that might occur following the first pruning will be eliminated with the second cuts.

Removal of infected wood is important to decrease the source of spores. Late spring is a good time to locate and remove disease portions of vines before vigorous adjacent shoots mask them. Remove the canker with a series of successive saw cuts to avoid overcutting. The final saw cut must show completely healthy tissue and no evidence of the pie-shaped sector of dead wood extending downward from the canker site. This type of surgery should be performed when there is little chance of rain.

Phomopsis

Phomopsis cane and leaf spot, caused by the fungus *Phomopsis viticola*, may cause serious disease incidents in very wet springs. Infection results in small spots or lesions on grape leaves, spurs, shoots, cluster stems, and canes. The injury can reduce yield. In years of severe infection losses can occur from: 1) shoots breaking off near the base due to lesions, and 2) fruit infection before harvest in cool wet weather.

Symptoms

Infections occur on leaves, shoots, clusters, and canes. The first evidence of shoot infection is a small oblong spot with black centers in the basal portion of the shoots. As the spots reach 1/4 of an inch long, the epidermal layers of the shoots crack. In heavily infested shoots the lesions coalesce giving a scabby appearance to the basal portion of the shoot. Heavily diseased shoots can be dwarfed or retarded and some may die. Later, when shoots are 1 to 2 feet long, shoot breakage can occur during strong winds. Shoot lesions become inactive during summer.

Spots also appear on flower cluster stems. If the infection is severe the cluster withers. These lesions also become inactive in summer, but early fall rains, combined with cool weather, may reactivate the fungus, resulting in isolated berry and bunch rotting.

During the dormant season, infected wood areas on basal portions of the canes appear bleached. Tissue in the vicinity of the original lesions and at the nodes is also whitish with black speckling. These black specks are the fruiting bodies, which develop during the dormant season, break through the surface and appear as minute, black, pimple-like pustules. They are the source of overwintering spores for the next season. Severely affected canes and spurs are more sensitive to low temperatures than healthy ones. The low temperatures can weaken the canes and kill the spurs.

Disease Cycle

Infection occurs in spring when shoots begin to grow. Rain splashes the spores from the overwintering fruiting bodies on diseased canes, spurs, and bark onto newly developing shoots. Infection occurs when free moisture remains on the unprotected green tissue for many hours; symptoms become visible shortly afterwards. Heavy and prolonged rains in late March and April, soon after bud break, are ideal for spring infection.

Prevention and Environmentally Sensitive Controls

Because spur and cane lesions provide most of the inoculum for new infections, reducing this source of disease is important. Carefully prune out badly infected canes to reduce carryover of spores.

In very wet springs (e.g. "El Niño" year), treat vines with a fungicide during the early shoot growth stages. Sprays applied at bud break when shoots are 1/2 inch in length and possibly again when shoots are 5 to 6 inches long will provide good control. An additional foliar spray may be necessary after very heavy spring rainfall. Wettable Sulfur in combination with copper gives adequate control. This combination also controls powdery mildew.

Pierce's Disease

Pierce's Disease (PD) is one of the few grapevine diseases that can kill vines in a short period of time. It is caused by a bacterium and is spread by certain kinds of leafhoppers known as sharpshooters. The bacteria multiply within the water-conducting xylem tissue of the vine, eventually plugging them and stopping the flow of water through the plant. Infected vines suffer severe water stress and quickly die. During major epidemics, losses to PD may require extensive replanting. PD typically occurs in localized areas, often referred to as 'hot spots.' These are habitats adjacent to the vineyard which are conducive to the development of the sharpshooters, and also include plants that are non-symptomatic carriers of the bacteria. It is important to determine if PD is present in your vineyard by looking for symptoms late in the summer or early in the fall. If vines are not affected control measures may not be warranted.

Symptoms

Symptoms are caused by blockage of the water-conducting system by the bacteria. Water stress begins in midsummer and increases through fall. Summer and fall symptoms are more reliable for positive identification of the disease than spring symptoms.

First symptoms mid- to late summer

The combination of these three symptoms is a definitive indication that PD is present:

1) Leaves become slightly yellow or red along margins in white and red varieties respectively. As the disease advances, leaf margins progressively dry or die (turn brown) in concentric zones (see figure 2).
2) Scorched leaves dry down and the blade falls, leaving the petiole attached to the cane (see figure 3).
3) Wood on new canes matures irregularly, producing patches of green, surrounded by mature brown bark (see figure 3).

Leaf symptoms vary among grape varieties. Pinot Noir and Cabernet Sauvignon have highly regular zones of progressive marginal discoloration and drying of blades. In Chenin Blanc the discoloration and scorching may occur in sectors of the leaf rather than along the margins.

Usually only one or two canes will show PD symptoms late in the first season of infection. Symptoms gradually spread along the cane from the point of infection out towards the end and more slowly towards the base. By mid-season some or all fruit clusters may wilt and dry up. Tips of canes may die back; roots may also die back. Climatic differences between regions can affect the timing and the severity, but not the type of PD symptoms. Hot climates accelerate symptoms due to moisture stress even when there is more than adequate soil moisture. Vines deteriorate rapidly after appearance of symptoms. Shoot growth of infected plants becomes progressively weaker as symptoms become more pronounced.

Spring symptoms of vines infected the previous year (chronically affected vines)

Infected vines exhibit delayed and stunted growth. Some canes or spurs may fail to bud out. New leaves (first 4 to 8 leaves) become chlorotic (yellow) between leaf veins (see figure 1). Scorching appears first in leaves at the cane's base (oldest leaves). Leaves are stunted and distorted with shortened 'zigzag' internodes.

From late April through summer PD infected vines may grow at normal rates, but the total new growth will be less than in healthy vines. In late summer leaf burning symptoms reappear.

The symptoms of PD can be easily confused with other diseases or phenomena that cause water stress, such as insufficient soil moisture or excessive salt concentrations.

Disease Cycle

The most important vector in the North Coast is the Blue-green sharpshooter. In coastal areas, riparian (riverbank) vegetation is the principal breeding habitat for blue-green sharpshooters, which have been collected from over 150 species of plants. These insects shift their feeding preferences as the season progresses always selecting succulent growth. Blue-green sharpshooters can also be found in ornamental landscapes in residential areas or parks. Woody ornamentals when pruned, especially in the winter, will produce spring growth that is very vigorous and succulent. This growth is often very attractive to the insect, even when the same plants would otherwise be minor feeding hosts.

Two other vectors that are able to transmit the disease are the green and the red-headed sharpshooters. Irrigated pastures, sump ponds, irrigation ditches or areas where Bermuda grass and other perennial grasses or sedges flourish and remain lush year-round are major sources of the green and red-headed sharpshooters. Although spread from these sources is not the most common, it has been documented in the North Coast.

Blue-green sharpshooter life cycle

The blue-green sharpshooter (see figure) has one generation per year. Adults overwinter mainly in riparian habitats, but also may be distributed at low density in areas with trees and shrubs. In late winter and early spring, adults become active in short flights in the natural vegetation. They begin moving into nearby vineyards for feeding and egg-laying once grape shoots are a couple of inches long. Eggs are laid beginning in April, depending on temperature. Most adults (80-90%) breed in riparian areas, hence the majority of the eggs are laid within riparian plants. Adults that have started to migrate will lay their eggs in vines at the edge of the vineyard. Their dispersal into the vineyard increases as natural vegetation dries up in the summer months. Most over wintered adults die out by the end of June.

The flightless immatures (nymphs) emerge from late April or early May through July and remain on the same plant where they had emerged from the eggs, thus the majority of the nymphs are found on riparian plants. As adults begin to emerge in late June they move deeper into the vineyard. At the beginning of September, when grape foliage is less succulent, sharpshooters begin to move back into nearby natural habitats.

Alternate hosts of the bacteria

Many plants harbor the bacterium without having symptoms of disease. Plant species vary in their role as reservoirs of the bacteria for disease spread. Plant species are highly variable in how easily the PD bacterium infects the plant, how rapidly it will spread and the maximum population size it will reach within the plant. The bacterium does not move systemically in all its plant hosts and must multiply in the plant for the vector to acquire it.

The most important reservoir for the bacteria is wild grapes. In this host, the bacteria multiply, spread systemically and reach the highest concentrations per unit of tissue. The more the bacteria multiply and move within the plant, the greater the probability that a vector can pick it up by feeding on the plant.

Grapevine susceptibility

Some vines infected during the season appear to recover from PD the first winter following infection. Recovery from PD depends on variety. In Cabernet recovery is high while in Chardonnay and Pinot Noir it is low. In more tolerant cultivars, the bacterium spreads more slowly within the plant than in more susceptible cultivars. Once the vine has been infected for over a year (i.e. bacteria survive the first winter) recovery is much less likely. Young vines are more susceptible than mature vines, possibly because the bacteria can move more quickly through younger vines that through older vines.

Rootstock species and hybrids vary greatly in susceptibility. Testing of rootstock plants show that *V. riparia* is rather susceptible; *V. rupestris* (St. George) and 420A are very tolerant. However, rootstock does not transfer resistance to susceptible *vinifera* varieties grafted on to it.

Climate, variety and age determine how long a vine with PD can survive. One-year old Pinot Noir or Chardonnay can die the year they become infected, whereas chronically infected 10-year-old Chenin Blanc or Ruby Cabernet can live for more than five years. Long before that, however, these chronically infested vines will cease to bear a crop.

Monitoring of the blue-green sharpshooter

In order to determine where the sharpshooters are coming from monitor the edge of the vineyard adjacent to a riparian zone, wooded areas, or landscape. Begin monitoring in early March with yellow sticky traps at least 4 by 7 inches in size. Place a minimum of six traps per vineyard block 100 to 200 feet apart. Check traps once a week beginning at bud break and more frequently after 2 or 3 days of warm weather. Remove insects from the trap after counting them and replace traps whenever they become excessively dirty or no longer sticky due to moisture. If more than an average of three sharpshooters are caught per trap per week, look for sharpshooters on host plants early in the morning when it is cool and they are less likely to fly away. To detect where the sharpshooters are entering the vineyard, a continuous strip of yellow sticky tape can be placed at the vineyard edge. Support the sticky tape every 10 to 15 feet with a stake. Once you detect areas in the tape with sharpshooters examine the adjacent vegetation to learn from which plants the sharpshooter are coming from.

Prevention and Environmentally Sensitive Controls

For establishing or replanting vineyards near a known or suspected PD 'hot spot' one should plant varieties that are less susceptible to PD. The first three hundred feet from

When infection is coming from well irrigated grasses, check this area with an insect net for presence of green or red-headed sharpshooters. If they are present prevent these vectors from breeding by weed control rather than by insecticide treatments.

Remove vines that have had PD symptoms for more than one year; they are chronically infected and are unlikely to recover or continue to produce a significant crop. They may also provide a source of infection for sharpshooters that will overwinter nearby and might reenter vineyards the next spring. Remove vines with extensive foliar symptoms and severe die back of canes even if it is the first year you have seen it. Mark slightly symptomatic vines in the fall; reexamine for symptoms the following late summer or fall and remove vines that have PD symptoms for a second year.

Studies have shown that insecticide treatments of vector habitats adjacent to vineyards reduced PD incidence, but the degree of control was not promising for very susceptible varieties such as Chardonnay and Pinot Noir.

The removal of blue-green sharpshooter breeding hosts and systemic hosts of bacteria from the riparian corridor is often prohibited or restricted. Several agencies from federal, state and local government have permit or similar authority over activities in or adjacent to the riparian area. In addition to addressing PD related concerns, any vegetation management plan must be acceptable or beneficial for wildlife and water quality and maintain other important values provided by the riparian habitat.

Powdery Mildew

Powdery mildew is the most serious and persistent disease in the North Coast with regards to control expenses and losses in yield. Nearly all vineyards will become infected if preventive control measures are not employed. Because wine flavor can be affected by as little as 3 percent berry infection, many wineries will not accept loads with any appreciable level of mildew.

Symptoms

Red blotchy areas appear on dormant canes. Young, succulent, rapidly growing tissue is most susceptible. Initial colonies may appear one week after the first spring rains on the undersides of leaves at the base of the shoot. These colonies can be detected as faint yellow chlorotic patches on the upper leaf surface. Initially the pathogen appears as white, web-like mat of stands over the infected tissue surface. Short root-like structures grow from these strands into the leaf tissue to draw out nutrients. On short stalks perpendicular to the surface, chains of spores are produced (see figure) and the colony takes on a white, powdery appearance. The short stalk of spores looks like a crew cut. Mildew colonies on leaves are usually found either on the underside of the exposed leaves or on both sides of well-shaded leaves.

Powdery mildew on young tissue will deform and dwarf the leaves and shoots. Early season infection interferes with fruit set and development. On young grapes it results in small, stunted berries, formation of scar tissue, and off-flavors. Scar tissue may crack open when the berries enlarge, allowing rot organisms to enter. Severely infected vines have lower photosynthesis rates that may impair the plant's ability to produce adequate amounts of sugar. On fruit and rachises the pathogen appears as white, powdery masses that may colonize the entire berry surface.

Late in the season, small, spherical, black fruiting bodies may be formed on the strand mats. They are primarily on the leaves but can also be found on rachis and other green portions of the plant. You can see them using a hand lens. Their appearance resembles pepper corns on the leaves. These fruiting bodies contain the sexual spores called ascospores.

Disease Cycle

Powdery mildew cannot grow on dead or dormant grape tissue. It survives the winter as dormant fruiting bodies on spurs and cordons or as dormant fungus strands under infected buds.

The fruiting bodies have a hard outer shell that encases the ascospores inside. Moisture in the spring from rain, sprinkler irrigation, long duration fog or heavy dew will swell the shell of the fruiting body forcing it to rupture. Wind gusts and water droplets pick up the ascospores. When they contact new growth, the disease is initiated in about 12 hours. Infection from ascospores often begins on the lower surface of basal leaves. Temperature plays a major role in how soon symptoms and signs are expressed. After infection mild weather favors rapid secondary reproduction that spread the disease to other leaves and fruits in the canopy. Spores germinate at leaf surface temperatures between 43° and 90°F, the optimum being 77°F. Rapid germination and fungus stand growth takes place at 70-86°F. At optimum temperatures, the generation time between spore germination and production of spores by the new colony is only 5 days. Temperatures below or above the optimum prolong generation time by up to 15 days. Spores and mildew colonies can be killed at extended temperatures above 91°F. At air temperatures above 95°F the fungus is destroyed. Powdery mildew will develop more abundantly in the shade than in bright or direct sunlight. The disease spreads most rapidly from an infection center in the direction of the prevailing wind.

If mildew was extensive in the previous season, red, stain-like scarring of old infections will be apparent on canes. If scarring is located close to buds, the bud may contain overwintering fungus strands. As shoots elongate in the spring the fungus from the buds grow on the surface of emerging shoots producing many spores. In cool springs, shoots produced from such buds should be examined frequently for the onset of disease. Infection often occurs on the second leaf of infected shoots.

The fruit is susceptible to infection from the beginning of development until the sugar content reaches about 8 percent. Established infections continue to produce spores until the berries contain 12 to 15% sugar. Old infections become inactive and the berries become resistant after the sugar content exceeds 15 percent. Powdery mildew usually does not infect leaves more than two months old unless they are growing in dense shade. Shoots, petioles and cluster parts are susceptible throughout the growing season.

Temperature plays a greater role in secondary disease development than moisture. However, free water (rain, dew or irrigation water) can cause abnormal spore germination and may wash spores from the tissue. Water lowers the temperature under the canopy and may actually help the development of surviving infections.

The fruiting bodies are produced late in the season when the days become cooler and the nights become longer. They are washed off the leaves and shoots into the bark of upper trunks and cordons during the fall rains. These fruiting bodies overwinter on the cordon and canes, down in the bark cracks and crevices. They reside there until the following spring.

Prevention and Environmentally Sensitive Controls

The control program is based on preventing the fungus from becoming established in the vineyard. Fungicides must be applied as protectants, before there is any sign of disease. Powdery mildew disease models have been developed that predict when a powdery mildew episode will occur. Sprays can be timed using the model and a weather station to measure temperatures and humidity.

An early-season application of wettable sulfur at bud break (0-2 inches growth) will prevent infections that could arise from mildew that overwintered in your vines. A second wettable sulfur application should be made in cool, wet springs when conditions are optimal for mildews development. Early sprays of micronized sulfur and copper hydroxide provide the best protection.

Mildew can be successfully controlled with applications of sulfur dust every 7-10 days until veraison. Sulfur dust is ineffective during cool temperatures. Berries are no longer susceptible to mildew infection once they reach about 8° Brix. Because all berries do not ripen at the same time, continue sulfuring until the average sugar test is 12 to 13° Brix.

If mildew does get established in the vineyard, it must be eradicated. This should be done with a high-volume washing using wettable sulfur and a surfactant. The eradication effect is likely due to the water and the surfactant. The wettable sulfur then provides protection against additional mildew infections. Effective eradication depends on the wash water penetrating and covering the vine canopy and clusters. In severe cases, several washings may be needed for adequate coverage and control. Liquid lime sulfur can also be used as an eradicant.

The biofungicide AQ10 contains fungal spores of a parasite that preys on the live powdery mildew present on the fruit, leaves, canes and stems of plants. AQ10 can be used effectively from budbreak to veraison, requiring at least two or three consecutive applications 7-14 days apart. Use when there is 3% powdery mildew infection or less. It is best to apply in the early morning or late evening when humidity in the field is at its highest. This assures maximum germination of AQ10.

Post-harvest treatments may be warranted in vineyards under heavy disease pressure or if your vineyard is difficult to get into in the early spring. Fall applications of wettable sulfur or liquid lime sulfur kill the overwintering fruiting bodies, thus reducing the inoculum for the following spring.

Grape Leafhopper

The grape leafhopper is the most widely distributed of the grape insects in California. Most wine grape vineyards do not require control measures. Damage varies according to vigor of the plant, location of the vineyard variety and season.

Description and Life Cycle

The adults are about one eighth of an inch in length pale yellow with reddish and brown markings. They overwinter as adults, and during warm weather they feed on any green vegetation in and around the vineyard. During wet or cold weather they take refuge among leaves, vegetation, and trash close to the ground. As soon as the vine growth starts in spring, the adults move to the grapevines and begin feeding.

Egg-laying starts about two weeks after the adults move to the vines and continues for approximately six weeks. Eggs are deposited singly in the epidermal tissue of both upper and lower surface of the leaf. They appear as minute, kidney-shaped blisters beneath the epidermis. A female lays 75 to 100 eggs. The nymph (immature form) emerges through a slit in the egg and leaf tissue in seventeen to 20 days after eggs are laid in the spring. The nymphs of the first generation appear in late May and June. They are semitransparent and have red eyes. They pass through five nymphal stages or molts, each resembling the other except for size and developing wings. When the fifth nymphal stage molts into adult it leaves the cast-off skin stuck to a leaf. Presence of cast-off skins means that adults are emerging which lead to the second-generation brood. First-brood nymphs are found primarily on the first six basal leaves on a shoot where they hatched.

The nymphs feed almost exclusively on the lower surface of the leaves. When disturbed, they often run with crab-like sideways movement. In approximately three weeks the nymph attains maturity, and in another three weeks adults mate and begin laying eggs midway on the cane on the youngest fully developed leaves. The nymphs of the second generation appear in July and August.

Damage

Both leafhopper adults and nymphs feed on leaves. Feeding is done by inserting the mouthparts into the leaves and sucking out the liquid contents. Leafhopper damage first appears as a scattering of small white spots or stippling; with continued feeding, the spots become more and more numerous until a pale-yellow blotching results from removal of the chlorophyll. The leaves may dry up and fall prematurely. The damage is in direct proportion to the number present. Canopy damage primarily occurs from July until the end of the season at the time of the second leafhopper generation. Defoliation is extremely rare but when it occurs it retards sugar accumulation in the grapes, thereby delaying ripening and lowering quality.

First generation brood begins to develop on basal leaves around bloom, but rarely result in enough leaf loss to affect vine growth, yield or fruit quality. Leaf damage from feeding is limited to basal leaves which are shaded by the time significant damage has occurred. Also, nymph populations during the first brood do not always reflect summer brood populations.

If numerous at harvest, leafhopper adults may be a nuisance to the pickers. Swarms of leafhoppers emerge from the vines when they are disturbed, flying into the eyes, ears, and nostrils of the pickers.

Monitoring

Monitoring is accomplished by counting the nymphs, the immature leafhoppers that cannot fly. Nymphs are counted on 15 to 20 leaves for a vineyard block (40 acres or less). Pick leaves throughout the vineyard. Walk around the perimeter of the vineyard stopping every 10 rows. Walk down the row at least five vines before picking a leaf to count. Record the average nymphs per leaf, the date and the block identification. During the first brood, select one basal leaf (second through sixth leaves). For the second brood, select a mid-shoot leaf. Take leaves from the shadier side, these usually has the highest count. Each vineyard should be sampled once a week.

In addition to monitoring leafhopper nymphs, estimate vine canopy damage. Begin by sharpening your observation skills. Pick a leaf with feeding damage, study it carefully, and then estimate percent loss of green color, chlorophyll. Expand your observational skills by selecting an exposed shoot on the outside or the canopy. Look at each of the 10 to 15 mature leaves on the shoot and again estimate loss of chlorophyll for the entire shoot. Now that you're trained, stand back and look at the entire vine, and make a judgment on loss of chlorophyll for the entire vine.

Prevention and Environmentally Sensitive Controls

Most wine grape vineyards don't require treatment for leafhoppers every year. Treatment is not necessary if nymphal populations do not exceed an average of 20 nymphs per leaf or canopy damage does not exceed 20 percent by harvest. This is based on an average, not on one leaf or vine that happens to have a high population. First-brood nymphs normally affect a small portion of total surface on a vine and should only be controlled if they become numerous enough to cause heavy damage and if there is no evidence of egg parasitism (see below).

Avoid over-irrigation and over-fertilization with nitrogen, because these produce overabundant vine growth, which is highly attractive to adult leafhoppers and more favorable to nymphal survival.

Several insect predators prey on leafhopper adults and nymphs. The most effective are spiders that live in the vine. A rapidly moving red predaceous mite called *Anystis* is very common in the spring. They attack first-instar nymphs.

Egg parasite

A parasitic wasp, *Anagrus,* is very effective in parasitizing the eggs of the leafhopper. This tiny wasp oviposits its egg inside the kidney-shaped grape leafhopper egg. The larva of the wasp feeds and develops inside the egg. Parasitism is visible from the outside. First a white mass appear towards one end of the egg, that later turns pink and finally the entire egg turns red. When the parasite is ready to emerge the black head can be seen at one end of the egg. The parasite makes a perfect round exit whole from which it emerges. Presence of the exit is indication of parasite activity. Anagrus has a short life cycle with approximately three generations per one leafhopper generation, thus being able to increase rapidly in numbers. If Anagrus is found to be active on the eggs of the first brood, it is very likely that it will control the leafhopper population causing a decrease in leafhopper population in the second generation. Even if a leafhopper population is above tolerance level, a decision about treating the first brood can be delayed to give *Anagrus* an opportunity for control.

Since grape leafhopper overwinters as an adult, *Anagrus* wasps need another host to be able to overwinter in its egg. Not all the hosts where Anagrus overwinters are known. *Anagrus* possibly overwinters in the eggs of the blackberry leafhopper in riparian habitats, in the eggs of prune leafhoppers in French prune trees and in the eggs of apple leafhopper in apple trees.

Mealybugs

In recent year outbreaks of the grape mealybug *Pseudococcus maritimus* have occurred in the Carneros region in the southern area of Sonoma County. Grape mealybugs have always been present at low levels throughout the region. It is speculated that the recent outbreaks may be due to a reduction in the use of pesticides for leafhopper control at provided background control.

Description and Life Cycle

Grape mealybug has a soft, oval, flattened, distinctly segmented body. The adult female is about 0.2 inch long and is covered with a white-mealy wax secretion. It has long filaments in the posterior end of the abdomen, and shorter ones along the lateral margins of the body. Eggs are laid in masses of up to 600 eggs inside a loose white-cottony secretion. The eggs are oval and yellow to orange in color. The crawlers that hatch from them are yellow to brown in color and are not covered with the waxy coating. Immature insects pass through several nymphal stages before becoming adults. The male forms a cottony cocoon 1/8-inch long underneath the bark where it passes through a pupa stage before becoming an adult. The adult male has a pair of wings.

The grape mealybug has two generations per season. They overwinter under loose bark in the trunk either as eggs or as newly hatched crawlers in on near the white, cottony egg masses. In spring the crawlers move to the base of the spurs and then onto the leaves in the expanding green shoots. In early spring the crawlers are first observed in the basal leaves. They reach maturity in mid-May to early June. Most females return to old wood to lay eggs under the bark that hatch from mid-June to early July. The summer generation crawlers then move out to the green portions of the vine to feed on fruit and foliage. It is this brood that produces almost all the fruit damage. In late August and September females from this summer generation return to old wood to lay overwintering eggs. A few individuals in each generation never leave the protection of the old wood, feeding at the basses of spurs, on callus tissue and below the bark.

The overwintering brood that appears on the foliage in spring is usually present in low numbers. The summer brood, hatching in June, may result in a population explosion and serious damage.

Damage

The major damage caused by mealybugs is the contamination of the fruit with its cottony egg masses, immature larvae, adults, honeydew (a sugar secretion produced by the insect) and the black sooty mold growing on honeydew. Wine grapes with fairly high levels of contamination may be rejected.

Susceptibility to grape mealybug varies by variety, plant architecture, and vigor. Vigorous vines are more likely to be infested than weak ones. Thus, the heaviest infestations in a vineyard are likely to be found in vigorous rows and end vines. Varieties that produce clusters close to the base of the shoot with fruit touching arms or cordons are more likely to have infested clusters than varieties where clusters hang freely. Early harvested varieties are much less likely to have serious fruit damage than are late maturing varieties. The fruit of cane-pruned vines hang free of old wood and are less likely to be seriously infested than fruit on spur-pruned vines. Cane pruning protects the fruit a little more in relation to it position to old wood where most mealybug eggs are laid. For the summer brood, however, some mealybugs lay their eggs on fruiting canes rather than on old wood of the head or trunk.

Monitoring

In the spring from April to June monitor the basal leaves. Populations of grape mealybugs can be detected by the presence of honeydew. Unless the populations are very high the overwintering generation is not treated.

The stage most susceptible to control is the crawlers. Presence of the male cocoon under the bark is an early indication that the overwintering generation females will begin to mature leading to the summer generation. After mating they lay eggs under the bark near the spurs. As the young move out they will be found on clusters touching old bark and on leaves or spurs close to the bark. Examine clusters touching the wood for the presence of young crawlers from mid-June to mid-July. Early detection is important for control. As mealybugs grow they secret honeydew where a black sooty mold grows. Sometimes growers do not notice the presence of summer brood mealybugs until the fruit is unsightly. If young mealybugs are found, examine other vigorous areas of the vineyard, especially those that have been infested in the past.

Monitoring bunches pre-harvest gives an indication of population levels and the areas in the vineyard that are of concern. This gives an indication of where to monitor the following spring. Examine five bunches on every tenth vine in every thirtieth row. Sample bunches closest to the bark and areas of vigorous vine growth. Bunches are recorded as infested if any signs of mealybugs are detected. If more than 2% of the bunches is infested, a more intensive survey to develop a map of infested areas is suggested.

In winter, monitor under the bark in arms, cordons and trunks for the presence of egg masses and young crawlers. Look for the yellow to orange eggs with a hand lens inside the white cottony masses. The presence of cottony secretions does not automatically mean that live mealybugs are present. These cottony strands can persist for a year or two after all the eggs hatch and crawlers are gone.

Prevention and Environmentally Sensitive Controls

Treating grape mealybug depends on prior history. In problem areas closely monitor all year. Infestation can develop rapidly with little warning or a heavy infestation may decline dramatically as a result of natural controls.

Ants protect the mealybugs by warding off natural enemies; in return the ants are able to harvest the honeydew produced by the mealybugs. Controlling honeydew seeking ant species significantly reduces mealybug populations. General predation is enhanced in the absence of ants. Ants are most effectively managed by spot-treating the trunk base.

A very effective predator is as small brown lady beetle, the mealybug destroyer (Cryptolaemus sp.). The adult is approximately 1/8 inches long with a light brown head and thorax with dark brown shell-like wings covering the abdomen. The larva has a soft, long, distinctly segmented body covered with a white cottony secretion. It mimics the appearance of mealybug and egg masses and thus blends into colonies of mealybug where it feeds. The beetle larva is approximately twice the size of a mature mealybug female and can be distinguish by the mouth. While the mealybug has a needle-type mouth the beetle has a pincer-type mouth. Both adult and larvae are voracious feeders and can effectively control mealybugs in the North Coast. The mealybug destroyer can be purchased from several suppliers of natural enemies. Releases can be made anytime during the field season when mealybugs are present. After releasing these predators, avoid placing insecticides. The goal is that the mealybug destroyer gets established in the vineyard.

At least five species of parasitic wasps attack grape mealybug in California. The impact of the different species varies from time to time and from place to place. Ants must be controlled to keep them from interfering with these natural enemies.

Spider Mites

Spider mites are a sporadic pest in the North Coast. There are two spider mite species commonly found on grapes: the Pacific spider mite, *Tetranychus pacificus* which is considered a more serious pest and Willamette spider mite, *Eotetranychus willamettei*, whose populations are less damaging. Environmental conditions and soil types strongly influence mite populations. Soils that are alkaline and light in texture, contributing to hot, dry, dusty vineyard conditions favor Pacific mite.

Description and Life Cycle

Female spider mite adults are approximately 0.5 mm long and are best seen with a hand lens with 14X or higher magnification. The body is oval shaped with distinctive hairs. Since Pacific spider mite is considered a more serious pest than Willamette mite it is important to be able to distinguish between the two. Both species have dark food spots along the sides of the body; these spots are more conspicuous in Pacific mites and minute on Willamette mites. Adult Pacific mite females vary in color from slightly amber to greenish. Later in the season or under high population densities adult females can turn reddish. Willamette mites are usually translucent. The first pair of legs of Pacific mite females are tan in color compared to Willamette front legs which are translucent or pale yellow. One needs to use a hand lens and it takes practice to identify these characteristics. Mixed populations of both species may occur.

Adult males of both species have pointed abdomens and are smaller in size (about one-half the size of the mature female). Males are usually found tending immature females. The male genitalia are different in both species. For positive species identification place several males in 70% alcohol (2 parts rubbing alcohol 1 part water) and take it to your local Cooperative Extension office. Spider mites overwinter as mature females, so early in the spring or late in the fall there are no males present for identification.

Females deposit eggs singly on the underside of leaves along the midrib and veins. The egg in both species is spherical and pearl white in color. The Willamette mite egg has a fine hair-like papilla that tapers at the top; no papilla is found on the Pacific mite egg. Spider mites go through three immature stages before becoming adults.

Both spider mites overwinter under grapevine bark as mature females. Female Pacific mites in diapause (overwinter resting state) exhibit a glistening, deep orange color and lack food spots. Diapausing Willamette mite females are glistening yellow and also lack food spots. Overwintering females of both species move to young foliage at bud break. Willamette mites prefer cooler temperatures and thus are more active in the early spring. Colonies of spider mites are found on the underside of the leaf under webbing. Both species produce many generations each year. During hot summer weather a pacific mite generation takes approximately 10 days.

Pacific and Willamette mite can also be distinguished by how they colonize the vine. Pacific mite colonies have a clumped distribution, while Willamette mite colonies tend to be more dispersed along the sides of the veins. Pacific mites prefer the exposed parts of a grapevine, particularly the top and the side that face the afternoon sun. Willamette mites seek the less exposed, shady and cooler part of the plant. High Pacific mite populations often produce extensive webbing and cause burning of the vertical shoot tips on the tops of the vines. Willamette mites produce very little webbing and show little preference for vertical shoot tips on the top.

Damage

Spider mite damage to vines is characterized by yellowing or bronzing of foliage. Feeding by small colonies of Pacific mite produce yellow spots on the upper leaf surface. Small colonies of Willamette mite produces yellowing along the veins. Yellowing of an entire leaf characterizes high densities of Willamette mites. Usually, no burn occurs unless vines are weak. On dark cultivars Willamette mite feeding causes a reddish coloration. High densities of Pacific mites will produce bronze discoloration and later, especially in hot weather, leaves turn dry and brown. Pacific mite damage in vineyards is often spotty and tends to occur in weaker areas.

Monitoring

Sampling for Pacific mite should begin in the middle of May. Sampling should continue every week. Within a vineyard block (40 acres or less), randomly select 15 vines to sample. From each vine, choose three leaves, one from the middle of each of three shoots. Select a leaf from a sun-exposed shoot on the top of the canopy, a second leaf from a sun-exposed shoot on the bottom of the canopy and a third leaf from within the bottom canopy that is continuously shaded. All sampling should be done on the south side of vines in east-west plantings and on the west side on north-south plantings. Examine the lower surface of the leaf with a hand lens and record presence or absence of spider mites and Western predatory mites (description below). You do not need to count the number of mites, one or more mite constitutes presence, and no mite constitutes absence. Tally the number of leaves with one or more spider mites and those with predaceous mites. Divide the number of leaves with spider mites by the total of leaves sampled to obtain percent infestation.

Prevention and Environmentally Sensitive Controls

Most wine grape vineyards don't require treatment for mites every year. Vineyard vigor, moisture stress and other pests influence the treatment decision. Troublesome Pacific mite outbreaks frequently occur year after year in areas of a vineyard that are weak or stressed. These spots are often a result of sand streaks, shallow soils, compacted soils, poor water penetration or distribution, nematodes, phylloxera, or any combination of factors. Correcting these cultural or irrigation problems can restore vine vigor and reduce Pacific mite activity. Proper irrigation scheduling and water application alleviates moisture stress. This may require touchup grading, altering irrigation and summer cover-cropping to improve water penetration. Keep vines healthy and vigorous by avoiding stress from over cropping, nutrient deficiencies, and irrigation deficits. Dust contributes to spider mite problems in vineyards. Control dust along heavily traveled roads using water or road oil. Summer cover crops may also reduce dust.

Treatment threshold is based on: 1) the percent infestation and 2) the ratio of spider mite to predatory mite. Willamette mite infestation seldom requires control in the North Coast. Grapevines can tolerate 65 to 75% of leaves infested with Pacific mites. When the predator-to-prey ratio is 1:2 (that is for every two leaves with spider mites one leave has a predator mite), the spider mite populations will decrease, regardless of the number of prey per leaf. When Pacific mite infestation is 65% and the predator-prey ratio is low (1:20) a treatment is required. But if the predator-prey ratio is (1:10) delay treatment a few days and re-evaluate population trends. Treatment may not be needed if predators are becoming numerous and the ratio moves towards (1:2).

The western predatory mite is the most reliable predator. The adult female is pear or teardrop shaped and is slightly larger in size than an adult female spider mite. The color varies depending upon how recently she has fed. They can be translucent white or slightly reddish. They do not have dark food spots in the body.

Western Predatory mites are constantly searching for prey, they move rapidly on the leaf and probe with the first pair of legs in quick up and down waving motion. This behavior contrast to that of spider mites that, since they are feeding on the leave, they tend to be sedentary.

Eggs of predaceous mites are oval. Freshly laid eggs are clear; they gradually turn milky and opaque before hatching. There are three immature stages. The female is usually found wedged in vein angles where she prefers to lay her eggs. The larval stages and adults attacks all stages of prey, but prefers spider mite eggs. With prey available and favorable conditions the western predatory mite can produce a generation in 7 days, which allows it to build up rapidly and control spider mites. They overwinter as mated females under the bud scales.

There are several other predators that contribute to the control of spider mites. The minute pirate bugs (Orius sp.) are tiny bugs with a black and white pattern on their wings. Both the adult and nymph feed on spider mites. The nymph lacks wings and thus is cream-colored and oval shaped with a long piercing mouth. The mite destroyer (Stethorus sp.) is a tiny jet-black lady beetle that feeds on spider mites. The elongated larvae are small, dull black, and covered with numerous hairs. The six-spotted thrips is a tiny, brownish slender insect characterized by three dark spots on each wing. They prefer webbing species of spider mites such as the Pacific mite. Willamette, which produces little webbing, is not preferred.

The above predators are adversely affected by certain material applied for control of other pests such as grape leafhoppers and thrips. Use pesticides that have the least adverse effect on these predators.

Spider mites can be controlled with narrow-range oil or soap sprays. These materials are more effective if applied early when populations are low.

Thrips

Thrips occasionally stunts young shoots in early spring by feeding in the developing leaves at the tip of the shoot. There are two species of thrips that can cause shoot stunting the Western flower thrips and the grape thrips.

Description and Life Cycle

Thrips are small insects, 1/25 inch long, with distinctive feathery wings. At the front end of the square head there are a pair of red eyes at the corners and a pair of antennae in the middle. Color varies from light yellow to brown.

The Western flower thrips, found on many plants, has five to seven generations per year. Populations peak in May and they overwinter in the adult and nymphal stages. Nymphs feed on the host through two nymphal stages then two resting nymphal stages that last 4 to 5 days and are spent in the soil debris. Adult thrips emerge from the soil and are attracted to grape blossoms. Vineyards with other vegetation in them or nearby can support large Western flower thrips populations. When weeds are disked or vegetation dries out they migrate to the vine.

The grape thrips overwinters in the soil as virgin females, emerging when grapevines begin to grow in the spring. They are restricted to grapes as a host and prefer tender foliage of white grape varieties. Eggs are laid in leaf and stem tissue. Nymphs appear in early April. They concentrate on shoot tips on tops of vines. There are five to six generations each year. Grape thrips nymphs also drop to the soil to pupate after completing feeding.

Damage

Thrips occasionally cause shoot and foliar damage in early spring when shoots are less than 12 inches long. This damage usually occurs in cool springs with slow growth. The young shoots may be stunted and thus fail to produce fruit. The damage occurs when the thrips are feeding in the developing leaves at the tip of the shoots. Later the damage appears as shortened internodes and scarred canes. The leaves fail to grow to normal size, they are deformed and cup shaped and the edges are bronzed. Adults and nymphs can be found in these damaged tips if they are examined while damage is occurring. Often the population has decreased by the time damage becomes overwhelmingly evident.

Monitoring

Thrips cause more damage to the shoots when vines leaf out early and when growth is slow during cool weather. Monitor for thrips when shoots are less than two feet long. Sharply tap the tip of the shoot onto a hard white surface. Look for fast moving elongated insects.

Prevention and Environmentally Sensitive Controls

Predators such as minute pirate bugs adults and immatures play a role in keeping populations in check. The minute pirate bugs (Orius sp.) are tiny bugs with a black and white pattern on their wings. The nymph lacks wings and thus is cream-colored and oval shaped with a long piercing mouth. This predator occurs naturally in the vineyard and it is important to conserve it by minimizing the use of insecticides.

Pyrellum, a plant extract insecticide, is a very effective material for thrips control that is non-disruptive to natural enemies.